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EDITORIAL

REHABILITATION

THE traditional way of expressing good fellowship and regard is to entertain one's friends at the festive table, for food, like wine, makes the heart glad. Similarly, nations may be happy or discontented according to the way in which they are fed. Plentiful supplies of good food foster the spirit of benevolence, co-operation and content, shortage does exactly the opposite, and breeds discontent and acrimony. At present mankind is at a cross-roads, and the future, be it for peace or war, depends upon how we can surmount the troubles which have piled up in the wake of the world war. Food has become a priority factor, and in no small measure the future depends on how present shortages can be resolved. Food production is the job of the agriculturalist, and in coping with his immense and urgent task he will need the help and advice of the scientists, and one of the most important of these is the veterinary surgeon. Before the war we lived apparently in a world of plenty; indeed, in a world in which many of the primary products produced by the farmer were in such excessive supply that markets could not be found which would repay the cost of production. This state of affairs was probably due in some measure to defects in distribution, for there were many people in the world existing on a subminimal dietary standard, whilst in other areas stocks of grain and other commodities were being destroyed or cast back into the sea.

Such was the state of affairs before 1939. Steps were taken to restore an economic balance in agriculture, but these methods were, unfortunately, restrictive in character, and the war with its great demands found agriculture at its lowest ebb. During the last six years great efforts have been made to step up production, and with considerable success, but the advent of peace has brought additional demands and no relief. Now, in addition to our own needs we have to make provision for the supply of the over-run countries, and also for our late enemies,

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for in both cases their own internal economy has been completely disorganised. Before the world can get back to a point approaching normal temporary relief measures are necessary, and the rehabilitation of men and their animals must be effected.

Many of the liberated countries were drained of their livestock by the enemy, and a restocking programme is an urgent necessity.

Livestock means food, clothing, transport, and they are essential for the fertility of the soil.

Restocking is no small task, and it also carries with it many advantages and many liabilities. If judicious selections are made the receiving countries may be able to up-grade their indigenous stock and improve health and physique. An outlet is at the same time provided for the stock of producer countries. Liabilities are the possibility of the introduction and spread of disease. New blood may lower the resistance of the progeny to indigenous disease. In the past there have been examples of the latter when European cattle have been introduced into areas subject to tick-borne diseases.

In this issue we publish U.N.R.R.A. reports relating to the South-West Pacific area, and from a perusal of these reports it will be seen that our colleagues in those parts are fully alive to the advantages and perils of stock rehabilitation. The authorities have shown wisdom, for they have sought the aid of people who are qualified and competent to advise, and an international Veterinary and Livestock Secretariat for the Far East has been formed. It is our hope that the close collaboration of the veterinary surgeons of the member countries born in the stress of post-war necessity may be continued into the happier times of the future. The British Commonwealth can play a leading rôle, for we have had much experience in these matters in the past, and from our varied stock we can supply every need. Here is a great opportunity to help our unfortunate neighbours and, incidentally, ourselves, and one in which the veterinary surgeon has a leading part to play.

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GENERAL ARTICLES

A SURVEY OF AVIAN SALMONELLOSIS IN GREAT BRITAIN

By R. F. GORDON and A. BUXTON

Weybridge.

DURING recent years the expansion of the poultry industry, together with the introduction of large hatcheries and intensive methods of farming, have increased the danger from bacterial infection among poultry in general, and especially among young stock. At the same time, methods of isolation and identification of the salmonella species have improved, with the result that the reported incidence of organisms of the salmonella group has increased during the last 5-10 years. The literature on this subject is very extensive, especially in the U.S.A., and in this communication it is only possible to give a brief outline of the work which has been recorded on avian salmonellosis, excluding *S. pullorum* and *S. gallinarum*, and a summary of the present position in Great Britain.

In a study of salmonellosis in poultry in the U.S.A., Edwards (1939) enumerated 16 different types isolated from 100 separate outbreaks over a period of 5 years. A list of 20 different species of salmonella organisms isolated from poultry was given by Edwards and Bruner (1939), who stated that poultry constituted the greatest reservoir of paratyphoid infection among domestic animals in the U.S.A. In a recent summary of their results of salmonella identification, these workers (1943) have named 42 different types as having been isolated from poultry. Table 1, reproduced from their paper, gives a list of these types, together with the number of outbreaks for each type.

Hinshaw, McNeil and Taylor (1944) give a comprehensive review of salmonellosis in the U.S.A. They list a total of 48 salmonella types which have been isolated from poultry. Table 2, which is reproduced from their paper, illustrates the high proportion of salmonellas which are common to both poultry and man, and emphasises the importance of controlling salmonellosis from a public health point of view. These authors also stress the danger to both attendants and dealers of contracting the disease from such infected stock, and the further possibility of human carriers being the disseminators of disease among poultry.

Salmonellosis is also frequently encountered in Europe. Lerche (1939) stated that the following types have been isolated from poultry in Germany: *S. enteritidis Breslau* (*S. typhi-murium*), *S. enteritidis* Gaertner (vars. Essen and Kiel), *S. suipestifer, S. newport, S. senftenberg, S. oranienburg,* and *S. anatum.* David (1944) reported a severe mortality in ducklings due to infection with *S. london.* Similar results have been reported by Schaaf (1936), Röhrer and Winand (1941), Pohl (1942). In Scandinavia, Hansen (1942) examined 308 strains isolated from poultry, of which 303 were *S. typhi-murium,* 3 were *S. enteritidis* (var. Essen), and 2 were *S. dublin.* European workers, in particular, have laid great stress on the public health aspect of this problem, and especially

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TABLE 1.

Types	Out-breaks	Cul-tures	Types	Out-breaks	Cul-tures
S. pullorum ...	492	497	*S. paratyphi B* ...	4	4
S. typhi-murium ...	409	629	*S. minnesota* ...	4	5
(*var. copenhagen*)	63	131	*S. hvittingfoss* ...	4	4
S. gallinarum ...	47	73	*S. aberdeen* ...	4	4
S. bareilly	47	51	*S. san-diego* ...	3	3
S. anatum	44	70	*S. illinois*	2	6
S. derby	33	35	*S. choleræ-suis* (*var.*		
S. oranienburg ...	28	34	*Kunzendorf*) ...	2	2
S. bredeney ...	27	34	*S. muenchen* ...	2	2
S. new-brunswick ...	26	39	*S. oregon*	2	2
S. newport	19	25	*S. manhattan* ...	2	2
S. give	18	26	*S. eastbourne* ...	2	2
S. newington ...	18	24	*S. cerro*	2	2
S. worthington ...	18	18	*S. amherstiana* ...	1	2
S. california ...	16	24	*S. saint paul* ...	1	1
S. senftenberg ...	15	18	*S. litchfield*	1	1
S. meleagridis ...	15	16	*S. dublin*	1	1
S. montevideo ...	11	14	*S. london*	1	1
S. kentucky ...	6	6	*S. rubislaw*	1	1
S. panama	6	6	*S. wichita*	1	1
S. enteritidis ...	5	10	*S. urbana*	1	1
			S. thompson ...	1	1

TABLE 2.

Group 1—

S. saint paul	*S. amherstiana*	*S. madelia*
S. california	*S. anatum*	*S. kentucky*
S. amersfoort	*S. meleagridis*	*S. minnesota*
S. oregon	*S. newington*	*S. tel-aviv*
S. manhattan	*S. new brunswick*	*S. pomona*
S. litchfield	*S. worthington*	*S. concord*

Group 2—

S. paratyphi B	*S. montevideo*	*S. lexington*
S. typhi-murium	*S. newport*	*S. illinois*
S. san diego	*S. muenchen*	*S. senftenberg*
S. derby	*S. typhi*	*S. aberdeen*
S. abortus equi	*S. enteritidis*	*S. rubislaw*
S. bredeney	*S. dublin*	*S. wichita*
S. choleræ suis	*S. eastbourne*	*S. hvittingfoss*
S. thompson	*S. panama*	*S. cerro*
S. oranienburg	*S. london*	*S. urbana*
S. bareilly	*S. give*	*S. simsbury*

Group 1 = Types originally found in birds.
Group 2 = Types originally found in man or other animals.

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the danger of human infection due to the consumption of infected eggs (Scott, 1930; Wanner, 1937; De Koning, 1936; Hedstrom, 1941; Muller, 1941; Gordon and Buxton, 1945 B).

The types of salmonella organisms infecting poultry in Australia do not appear to be so variable. According to Hart (1936) and Dumaresq (1938), *S. pullorum* and *S. gallinarum* are the two most commonly encountered, and Atkinson and Woodroofe (1944) have reported the isolation of *S. typhi-murium* from ducks and turkeys. In a survey of salmonellosis in S. Africa, Henning (1939) stated that the most important cause was *S. gallinarum*, and added that *S. pullorum*, *S. typhi-murium*, *S. anatum*, *S. amersfoort*, and *S. typhosum* had also been recovered from poultry. This worker also emphasised the importance of salmonella epidemics among poultry when he wrote that infection of birds with different types of salmonellas was much more varied and widespread than in mammals, and the losses sustained from this group of organisms was probably far greater than those resulting from any other cause.

In Great Britain infection of poultry with members of the salmonella group (other than *S. pullorum* and *S. gallinarum*) has not been so varied as in the U.S.A. Doyle (1927) reported a severe outbreak of *S. typhi-murium* in chicks, and Gaiger and Davies (1930) investigated a similar outbreak in ducklings due to *S. anatum*, which was later re-examined by Lovell (1932) and Hole (1932) and identified as *S. enteritidis*. Warrack and Dalling (1932) carried out a small investigation into *S. enteritidis* infection in ducks. Garside and Gordon (1940) described an outbreak of *S. typhi-murium* in ducklings, and McGaughey (1932) recorded paratyphoid infections in chicks caused by organisms which were not completely identified. Gordon and Garside (1944) carried out an extensive investigation regarding the infection of ducks and ducklings with *S. enteritidis* (var. Essen), and Gordon and Buxton (1945 A) have reported two serious outbreaks of fatal septicæmia in chicks due to *S. thompson*.

Present Investigation

This survey of the incidence of salmonella organisms in poultry in England and Wales is based on the records of *post-mortem* examinations carried out in the routine poultry department of the Veterinary Laboratory, Ministry of Agriculture, Weybridge, during the years 1933-44. It will be advisable at the outset to consider some of the advantages and some of the limitations of the data presented. In the first place, the laboratory is the largest carrying out a routine poultry *post-mortem* service in this country, and specimens are received from all parts of England and Wales and not only from a selected area. The number of specimens received over the period is significantly large, and evenly spread over the twelve years reviewed. During the last four years of the survey, all outbreaks of disease in some 2,000 flocks included in the accredited poultry breeding scheme were investigated at this laboratory. The data, therefore, can be considered to be a reasonably good index of the occurrence and relative incidence of salmonellosis in poultry in this country. Furthermore, there have been few staff changes, and over the whole period the primary examinations have been made, with few exceptions, by one of the authors (R.F.G.). As far as the incidence of specific disease

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in chicks is concerned, the data is nearly complete, since all chicks received for *post-mortem* examinations were subjected to bacteriological examination, irrespective of the history or autopsy findings.

One of the most serious limitations of the data is that until 1943 complete typing of the organisms isolated, other than *S. pullorum* and *S. gallinarum*, was not carried out, and it is possible that a few salmonella organisms may have been wrongly identified. During the years 1933-43 the following routine procedure was adopted: From all chicks received for examination, cultures were made from the liver, in nutrient broth, on MacConkey agar plates or on agar slants. On some occasions cultures were also made from hearts and yolk sacs. After incubation of the cultures overnight at 37° C., non-lactose fermenting colonies were transferred to three carbohydrates, lactose, maltose and dulcite. Organisms producing a growth in all three carbohydrates without fermentation, or more rarely fermenting maltose with acid or with acid and gas production, were regarded as *S. pullorum*, and confirmed by tube agglutination tests carried out in a water bath at 56° C., with *S. pullorum* serum. Organisms which failed to ferment lactose, but produced acid without gas in maltose and dulcite, were regarded as *S. gallinarum*, and confirmatory tube agglutination tests were carried out. Organisms failing to ferment lactose, and producing acid and gas in maltose and dulcite, were considered as suspicious salmonella strains and tube agglutination tests were carried out against *S. typhi-murium* and *S. enteritidis* sera only, and a diagnosis made accordingly. It is possible, therefore, that salmonella organisms other than *S. typhi-murium* and *S. enteritidis* which failed to be agglutinated by the sera used may have been discarded; but in our search of the records, few organisms giving these carbohydrate reactions and failing to be agglutinated were found. Similarly, it was possible that salmonella organisms possessing common antigens with *S. typhi-murium or S. enteritidis* may have been wrongly typed, but during the year 1939 a representative number of cultures were examined by the late Dr. W. M. Scott, who reported that they were typical *S. typhi-murium* and *S. enteritidis*, as labelled by us, and that no other types were present.

A bacteriological examination was not made in the case of all adult fowls, but only when a definite diagnosis could not be made on the macroscopic *post-mortem* lesions, or when the history suggested such a course to be necessary. The bacteriological examinations in adults were carried out in the same manner, cultures usually being made from liver and bone marrow. In the case of adults found to be reactors to the *pullorum* agglutination test and sent for confirmation, cultures were usually made from the liver, spleen, gall bladder, heart, ovary and, in a limited number of cases, from the intestinal tract.

During 1943, in view of the increase of salmonella organisms isolated from outbreaks in chicks, and the occurrence for the first time of *S. thompson*, it was decided to type in detail all salmonella organisms isolated. The procedure adopted was as follows: The primary examination of chicks was carried out, as before, by the inoculation of nutrient broth and MacConkey agar plates with material from livers and hearts. After 24 hours' incubation, non-lactose fermenting colonies were examined, and those not confirmed as *S. pullorum* or *S. gallinarum* were retained for further examination.

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Bacteriological Examination

After preliminary identification, those strains suspected as being members of the salmonella species were subcultured onto agar slopes, and incubated at 37° C. for 18 hours, and then kept at room temperature until a more complete typing could be carried out.

Biochemical Tests: Organisms which fermented maltose, glucose, dulcite, mannite and sorbite with production of acid and gas, but failed to ferment lactose, saccharose and salicin, produced slight alkalinity in litmus milk after 48 hours and were negative to the indol test, were retained for serological examination. An agar slope and 10 ml. of peptone broth were sown at the same time as the carbohydrates, and used for the preparation of suspensions for agglutination tests.

Serological Tests: Slide agglutination tests were carried out in the first instance, using a polyvalent salmonella serum, a non-specific salmonella serum (both supplied by the Oxford Standards Laboratory), and O sera prepared from *S. typhi-murium, S. paratyphi C., S. enteritidis* and *S. anatum.* (The most satisfactory results were obtained by using high titred O sera diluted with normal saline to give a final titre of 1/50-1/70, and preserved by the addition of a few drops of chloroform.) From these tests it was possible to assess whether the culture under examination was in the specific or non-specific phase, and to which of the four main salmonella groups it belonged. A further examination was then carried out to identify the type by using H specific and H non-specific sera related to the somatic antigen of the culture.

All slide test results were confirmed by carrying out tube agglutination tests to the full titre of the undiluted sera employed. O antigens were prepared from the remains of the growth on the agar slope after the slide tests had been completed. Approximately 2-3 ml. of sterile normal saline were added to the culture tube and the growth removed with the aid of a platinum loop and suspended in the saline. This suspension was transferred to a second tube, and after 4-5 volumes of absolute alcohol had been added, it was allowed to stand for 4-5 hours at room temperature until a deposit had settled, leaving a clear supernatant fluid. With the aid of a pasteur pipette, a small quantity of the deposit was resuspended in sterile normal saline to give a density of approximately tube No. 2 of Brown's opacity scale. This suspension was used for somatic agglutinations, and the tests were carried out in a waterbath at 52° C. for 18 hours.

H. antigens were prepared from 10 ml. of an 18-hours peptone broth culture by adding 10 drops of 40 per cent. formalin, shaking, allowing to stand for 2 hours at room temperature, and then adding 10 ml. of normal saline. H. agglutination tests were incubated in a waterbath at 52° C. for 2 hours, and after the tests had been read they were replaced in the waterbath and a final reading was made after a further 18 hours' incubation.

In addition to agglutination tests carried out against H specific and non-specific sera, the identification of some individual non-specific factors was confirmed by carrying out agglutination tests against single factor absorbed sera in dilutions of 1/20.

Certain strains, when first isolated, were found to be in the non-specific phase. In order to demonstrate the specific phase, such strains were sub-cultured, using the Craigie tube method, with the appropriate non-specific serum, and using the technique described by Bridges and Taylor (1944).

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It was found that almost without exception, all strains of *S. thompson* when first isolated from poultry were in the non-specific phase. Usually, passage through Craigie tubes, using *S. paratyphi B* non-specific serum (1, 2. . .) in the medium, was adequate for changing the phase of *S. thompson* and for demonstrating the presence of a specific antigen. In the case of 6 cultures, however, this technique was not successful, even after several passages through Craigie tubes and peptone broths (Scott, 1926) containing *S. paratyphi B* non-specific serum. A further attempt was made by repeating these passages and using non-specific *S. thompson* serum (1, 5. . .). As was expected, this rendered some of the cultures rough, but with one strain it was possible, after this treatment, to demonstrate an agglutinability of 1/800 against *S. thompson* specific H serum (titre 1/16,000).

Incidence of Salmonella Organisms in Chicks

Table 3 shows the incidence of salmonella infections in chicks. The term chick is used to denote young stock of approximately day-old to 4 weeks of age, and includes chicks, ducklings, pheasant chicks, turkey poults and goslings. Since bacillary white diarrhœa is the predominant disease in chicks it is shown separately, and the other salmonella organisms, with the exception of *S. gallinarum* (fowl typhoid), are grouped under the heading "Salmonellosis." The term salmonellosis, therefore, refers throughout to outbreaks of disease in chicks caused by organisms of the salmonella group other than *S. pullorum* (bacillary white diarrhœa) and *S. gallinarum* (fowl typhoid). With the isolation of a variety of salmonella types from chicks this term was adopted in order to avoid confusing the poultry farmer, and includes such previously used terms as aertrycke infection, keel disease and enteritidis infection. The second commonest specific disease of young chicks, cæcal coccidiosis, is also shown separately, and under the heading, miscellaneous diseases, are grouped non-specific conditions, such as chilling (a common cause of mortality in chicks and associated with incubation or brooding errors), dietetic disturbances, vitamin deficiencies and fungoid diseases.

Specimens of chicks sent for examination are invariably received in consignments of from 2-10 chicks, and on the average 4 chicks were examined from each group. The figures throughout this table refer to groups of chicks and not to individual chicks examined, and although the organisms may have been isolated from several chicks in a group they are only referred to as one isolation (column II of Table 3). When further chicks were received for confirmation from the same outbreak, or were known to have originated from the same source, then only one outbreak is shown under column I of Table 3. The percentage occurrence of the various diseases based on the total number of groups of chicks examined is shown in column III of Table 3.

It is impossible to assess the exact importance of salmonellosis, since the mortality associated with different outbreaks can vary so widely. It must be remembered that in chicks, salmonella organisms give rise to fatal outbreaks of disease in which mortality may vary from 15 to 100 per cent. of the entire hatch, and that the losses in any one outbreak will be influenced by the size of the hatch and the form of husbandry in use. For example, in one outbreak of *S. thompson* in 1943, studied by Gordon and Buxton (1945 A), which occurred in a large

TABLE 3.

Occurrence of Salmonellosis in Chicks during the Period 1933-1944.

YEAR	*Pullorum Disease (S. pullorum)*				*Salmonellosis*			*Fowl Typhoid (S. gallinarum)*			*Coccidiosis*		*Miscellaneous*	
	Total Groups of Chicks examined	Actual No. of Outbreaks confirmed	Total Groups of Chicks in which *S. pullorum* isolated	Per cent. of total Groups of Chicks examined	Actual No. of outbreaks confirmed	Total Groups of Chicks in which Salmonella organisms isolated	Per cent. of total Groups of Chicks examined	Actual No. of Outbreaks confirmed	Total Groups of Chicks in which *S. gallinarum* isolated	Per cent. of total Groups of Chicks examined	Total Groups of Chicks in which coccidiosis diagnosed	Per cent. of total Groups of Chicks examined	Total Groups of Chicks	Per cent. of total Groups of Chicks examined
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Col. 3	Col. 2	Col. 3	Col. 2	Col. 3
1933	433	134	138	31.9	10	13	3.0	5	6	1.3	76	17.5	200	46.2
1934	422	141	144	34.1	14	15	3.5	—	—	—	84	19.9	179	42.4
1935	368	119	131	35.6	3	3	0.8	1	1	0.27	82	22.3	151	41.0
1936	282	73	77	27.3	6	6	2.1	—	—	—	44	15.6	155	54.9
1937	351	69	71	20.2	8	9	2.6	—	—	—	66	18.8	205	58.4
1938	359	93	102	28.4	13	15	4.1	—	—	—	51	14.2	191	53.2
1939	488	117	120	24.6	18	22	4.5	—	—	—	87	17.8	259	53.1
1940	423	101	106	25.1	9	16	3.7	—	—	—	49	11.6	252	59.6
1941	424	87	97	22.9	19	20	4.7	—	—	—	47	11.1	260	61.3
1942	834	178	188	22.5	25	26	3.1	2	2	0.24	133	15.9	485	58.1
1943	903	186	193	21.4	28	39	4.3	—	—	—	150	16.6	521	57.6
1944	1291	267	314	24.3	60	89	6.9	—	—	—	204	15.8	684	52.9
Total	6578	1565	1681	25.5	213	273	4.1	8	9	0.14	1073	16.3	3542	53.8

central hatchery, the infection extended over ten consecutive hatches. Each hatch involved some 2,000 chicks, and outbreaks spread in purchased chicks to 13 separate farms, and while this is only referred to in column I of Table 3 as one outbreak, many thousands of chicks were involved. Similarly, in an epidemic of *S. typhi-murium* in ducklings, reported by Garside and Gordon (1940), the losses amounted to 1,000 ducklings per day, with a total death-rate of 30 per cent. in a flock of 57,000 ducklings.

The same conditions pertain to bacillary white diarrhœa, which may also under modern conditions of intensive hatching become endemic in a hatchery and spread over many hatches, so that the incidence of salmonellosis can be fairly compared with that of bacillary white diarrhœa. The incidence of salmonellosis has probably no real relationship to that of coccidiosis and miscellaneous disorders, since the same epidemiological conditions do not pertain, and the losses in each outbreak of these latter conditions may be much less severe.

During the twelve years reviewed, salmonella organisms other than *S. pullorum* and *S. gallinarum* were isolated from 273 groups, or 4.1 per cent. of the total groups of chicks examined, and involved 213 separate outbreaks. The incidence of salmonellosis, therefore, was approximately one-sixth that of bacillary white diarrhœa, which was consistently the most important cause of mortality in chicks, 25.5 per cent. of the total groups examined. Similarly, the number of outbreaks and percentage occurrence of salmonellosis were not so great as those of cæcal coccidiosis, although for the reasons discussed it is probable that the actual losses were as severe. Outbreaks of fowl typhoid (*S. gallinarum*) in chicks were of relatively small importance, and only eight outbreaks were encountered in the last twelve years.

The most noticeable feature of this table is the increase in the actual number of cases of salmonellosis during the last three years, 1942-1944. The total outbreaks for the first nine years of the survey, 1933-41, were 100, or an average of 11.1 outbreaks per year, and for the last three years 113 outbreaks, or an average of 37.6 outbreaks per year. This is a numerical annual increase of more than 200 per cent., and more than half of the 213 outbreaks recorded during the twelve-year period occurred during the last three years. Owing to the increased number of chicks examined during the three years, 1942-44, the increase in the percentage incidence of the disease is not so marked, although the percentage incidence during 1944 was 6.9 per cent., or 2.8 per cent. higher than the average incidence of the disease during the twelve years, an increase of over 68 per cent.

The numerical annual increase in salmonellosis and the occurrence of the new strains are shown in Figure 1. The increase in the percentage incidence of salmonellosis is shown in Figure 2, and compared with the annual percentage incidence of bacillary white diarrhœa and coccidiosis.

Strains Isolated

Table 4 shows the distribution of the various strains of salmonella organisms isolated from poultry during the twelve years, 1933-44. The table includes the isolation of organisms from adult birds in addition to chicks. As in Table 3, the annual total for each strain is subdivided into separate outbreaks confirmed, and total isolations of the organisms. As is to be expected, the outbreaks and

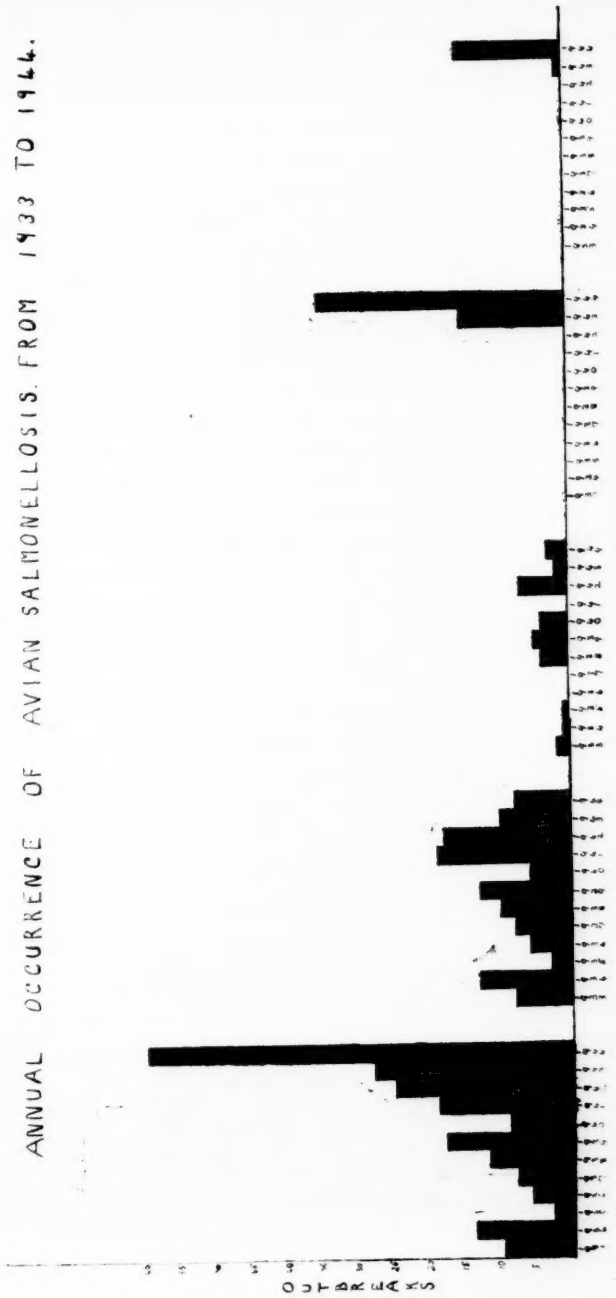
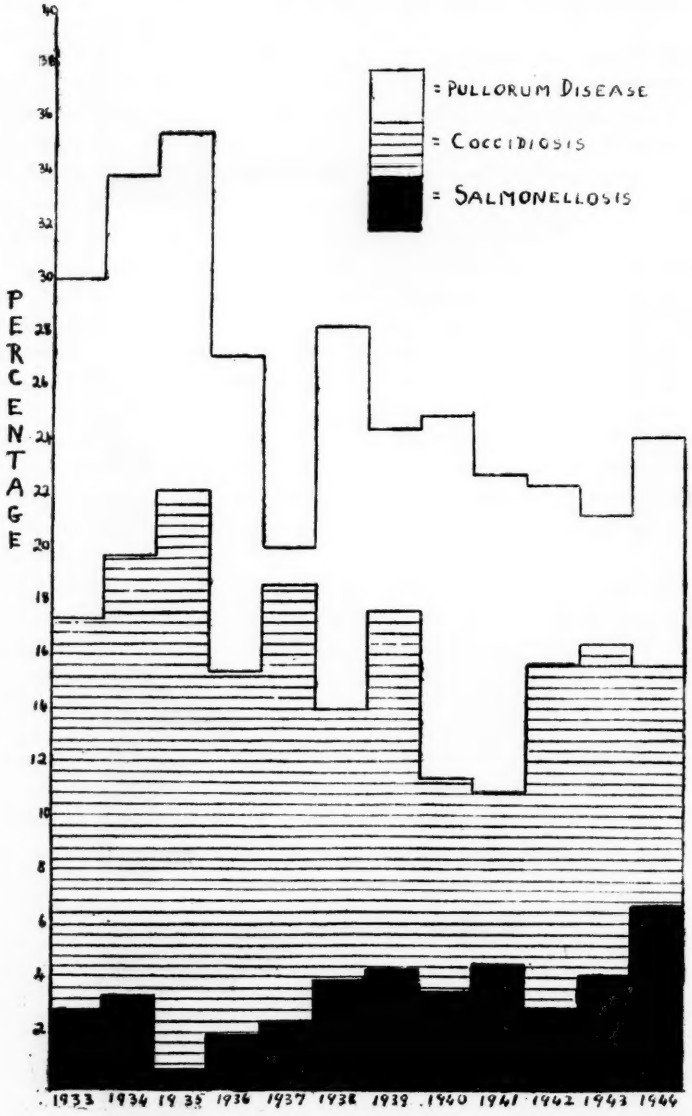

ANNUAL OCCURRENCE OF AVIAN SALMONELLOSIS. FROM 1933 TO 1944.
OUTBREAKS

Fig. 1.

Fig. 2.

PERCENTAGE INCIDENCE OF INFECTIOUS CHICK DISEASES



isolations of *S. pullorum* were very greatly in excess of other strains. In addition to chick outbreaks, a number of the isolations of *S. pullorum* were from adult fowls sent for confirmation of the rapid pullorum test in the field. The second greatest number of outbreaks and isolations was of *S. gallinarum*, and in this respect it should be remembered that this organism, unlike other members of the salmonella group, causes fatal epidemics in adult fowls, and, as will be seen from Table 3, only rarely causes outbreaks of disease in chicks. Conversely, *S. pullorum* rarely causes fatal epidemics in adult fowls, while the other strains of salmonella organisms are not known to be fatal to mature birds.

The most important point to be noted from Table 4 is that until 1943 the only organisms isolated other than *S. pullorum* and *S. gallinarum* were *S. typhi-murium* and *S. enteritidis*. The possibility that other types may have been present in earlier years and inadequately classified has already been discussed. Allowing for this possibility, it will be seen that the commonest organism isolated over the twelve years has been *S. typhi-murium*, 163 isolations from 122 outbreaks. These outbreaks have been fairly evenly distributed over the period reviewed and show an average of 10.2 outbreaks annually. The second commonest organism encountered has been *S. thompson*, 79 isolations from 50 outbreaks. Since this organism has been only isolated during 1943 and 1944, the average number of outbreaks is 25 per annum, or more than twice the annual incidence of *S. typhi-murium*. The third commonest organism has been *S. enteritidis*, and again the outbreaks have been fairly constant at 2.4 per annum. The remaining organisms, *S. california*, *S. montevideo*, *S. bareilly* and *S. anatum*, have only been isolated during 1944, with the exception of a single outbreak of *S. california* encountered in 1943. In addition, six outbreaks were recorded during 1944 in which the organisms isolated were members of the *para* C. group, and reference has already been made to the difficulty experienced in identifying these cultures. In another outbreak an organism in the *typhosum* group was isolated, while in three further outbreaks organisms belonging to the salmonella group, but which could not be fully identified, were isolated.

Species of Poultry in which Salmonella Organisms were Encountered.

Table 5 illustrates the various species of poultry from which the different strains of salmonella organisms were isolated. Owing to the predominance of bacillary white diarrhœa and fowl typhoid as avian diseases, the great majority of isolations were of *S. pullorum* and, to a lesser degree, *S. gallinarum*, from chicks and adult fowls.

S. pullorum was also isolated from ducklings, turkey poults, pheasant chicks, guinea fowl and a sparrow. *S. gallinarum* mainly occurred in adult fowls, but 9 outbreaks were encountered in chicks. Only 1 outbreak of fowl typhoid was recorded in turkeys. This is surprising, since in the U.S.A. it is stated to be one of the most serious diseases of turkeys (Hinshaw, 1930). Salmonellosis was most commonly encountered in chicks, and the second most important host was ducklings. *S. typhi-murium* was the most ubiquitous organism, and was isolated from chicks, adult fowls, ducklings, ducks, turkey poults, goslings, geese, pheasant chicks, pigeons, and on one occasion from an ornamental duck. *S. enteritidis* occurred in chicks, fowls, ducklings, ducks, turkey poults and turkeys. All the isolations of *S. thompson* were made from chicks, with the exception of one from

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Years	S. Pullorum		S. Gallinarum		S. Typhi-murium		S. Enter-itidis		S. Thompson		S. Monte-video		S. Bareilly		S. Cali-fornia		S. Anatum		Para C. Group Untyped		Typhosum Group Untyped		Salmon-ellas Untyped		Total	
	C.	O.	C.	O.	C.	O.	C.	O.	C.	O.	C.	O.	C.	O.	C.	O.	C.	O.	C.	O.	C.	O.	C.	O.	C.	O.
1933	145	134	21	18	11	8	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	179	162
1934	164	141	26	21	15	13	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	206	176
1935	142	119	26	23	3	3	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	172	146
1936	89	73	7	7	6	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	102	86
1937	82	69	14	12	9	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	105	89
1938	117	93	15	14	11	10	4	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	147	121
1939	188	117	21	9	22	13	6	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	237	144
1940	151	101	9	6	11	6	6	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	177	117
1941	137	87	26	15	21	19	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	184	121
1942	216	178	26	15	19	18	7	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	268	218
1943	285	186	9	6	18	10	4	2	22	15	—	—	—	—	1	1	—	—	—	—	—	—	—	—	339	220
1944	387	267	8	5	17	8	5	3	57	35	2	2	2	1	2	1	1	1	6	6	1	1	3	3	491	333
Total	2103	1565	208	151	163	122	36	29	79	50	2	2	2	1	3	2	1	1	6	6	1	1	3	3	2607	1933

TABLE 4

(C = Cultures) (O = Outbreaks)

DISTRIBUTION OF STRAINS OVER THE YEARS 1933-44.

Strains	Chicks	Adult Fowls	Ducklings	Adult Ducks	Poults	Adult Turkeys	Goslings	Adult Goose	Pheasant Chicks	Pigeons	Guinea Fowl	Golden-eyed Sea Duck	Sparrow	Total	
S. pullorum	1677	419	1	—	2	—	—	—	2	—	1	—	1	2103	2311
S. gallinarum	9	198	—	—	—	1	—	—	—	—	—	—	—	208	
S. typhi-murium	97	5	35	6	5	—	5	1	3	5	—	1	—	163	296
S. enteritidis	18	3	11	1	2	1	—	—	—	—	—	—	—	36	
S. thompson	76	1	2	—	—	—	—	—	—	—	—	—	—	79	
S. montevideo	2	—	—	—	—	—	—	—	—	—	—	—	—	2	
S. bareilly	2	—	—	—	—	—	—	—	—	—	—	—	—	2	
S. california	3	—	—	—	—	—	—	—	—	—	—	—	—	3	
S. anatum	1	—	—	—	—	—	—	—	—	—	—	—	—	1	
Para C. Group—untyped ...	5	—	1	—	—	—	—	—	—	—	—	—	—	6	
Typhosum Group—untyped	1	—	—	—	—	—	—	—	—	—	—	—	—	1	
Salmonellas—untyped ...	1	—	1	—	—	—	1	—	—	—	—	—	—	3	
Total	1892	626	51	7	9	2	6	1	5	5	1	1	1	2607	

TABLE 5

Distribution of Salmonella Strains in Different Species of Birds.

an adult fowl and two from groups of ducklings. The other types recorded were isolated only from chicks.

Histories of Outbreaks Studied

S. typhi-murium and S. enteritidis.

It will have been noted from the review of the literature that the only organisms of the salmonella group previously reported in this country were *S. typhi-murium* and *S. enteritidis*, and these only in chicks and ducklings. It is not therefore proposed to describe outbreaks in these species. During the present survey, however, *S. typhi-murium* was also isolated from an extensive outbreak of disease in a flock of over 900 geese of ages varying from 4-8 months. Deaths first commenced in the younger groups, and for three months mortality averaged 1 to 2 geese daily. Some 33 geese were examined, and the primary cause of death was established as gizzard worm infestation (*Amidostomum anseris*), and a large number of geese were also affected with coccidiosis of the kidneys. *S. typhi-murium* was isolated from the majority of the carcases examined. The birds had recently been shipped from Ireland, and a similar mortality was experienced on a second farm purchasing geese for fattening from the same source. Again, *S. typhi-murium* was found to co-exist with gizzard worm infestation and kidney coccidiosis.

Unfortunately, no information was available regarding the outbreaks of *S. typhi-murium* encountered in turkey poults and pheasant chicks.

Similarly, no information was received regarding the pigeons examined under the routine *post-mortem* service, and from which *S. typhi-murium* was isolated. During the past twelve months a few sporadic deaths have occurred in healthy pigeons kept at this laboratory, and on autopsy *S. typhi-murium* was isolated from the majority of them. No clinical symptoms were observed, the apparently healthy pigeons being found dead in the pigeon loft. The organism isolated showed distinctive features in that all cultures from these pigeons failed to ferment maltose, or fermented that carbohydrate only after 7 to 8 days' incubation. Serologically, this pigeon strain, although identical with the other strains of *S. typhi-murium* isolated in its specific and non-specific flagellar antigens, possessed only somatic antigens IV and XII. In this respect the strain would appear to be *S. typhi-murium* (var. Storrs), as described by Edwards (1935). In addition, a culture showing identical characteristics was received from D. L. Hughes, A.R.C. Experimental Farm, Compton, which had been isolated from a pigeon affected with psittacosis.

One outbreak of *S. enteritidis* was encountered in turkey poults in 1944, and extended over three hatches. In the first hatch of 90 poults the mortality was 100 per cent., in the following hatch there were 20 survivors out of 112 poults (82 per cent. mortality), and in the final group, which was hen-hatched, 13 died out of 40 (30 per cent. mortality). The losses all occurred during the first 10 days of life.

S. thompson.

This organism was first isolated from poultry in this country during 1943, and two extensive outbreaks in chicks have been recorded by Gordon and Buxton (1945 A). Two outbreaks have also been encountered in ducklings, but, unfor-

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tunately, full histories were not available. In one case some 60-70 ducklings of approximately 4 weeks of age died after showing symptoms over a period of 4 days. In the other outbreak there was 100 per cent. mortality in a group of 50 ducklings.

The other types of salmonella organisms referred to in this survey have not so far been recorded in Great Britain. We are informed (private communication, Emergency Public Health Laboratory Service) that *S. anatum, S. barcilly* and *S. montevideo* have all recently been isolated from the mesenteric glands of healthy pigs at slaughter, from dried egg, and from human cases in this country during the war. *S. california* has been isolated from a sample of dried egg.

S. california.

This organism was first isolated by Edwards, Bruner and Hinshaw (1940) during an outbreak of disease in turkey poults in which a 26 per cent. mortality occurred, but intercurrent diseases were also present. Edwards and Bruner (1943) report the isolation in the U.S.A. of 24 cultures of *S. california* from 16 outbreaks in fowls, one from an outbreak in swine, and one from man.

In the present survey *S. california* was isolated on three occasions, in two separate outbreaks in chicks and once in chicks concurrently with *S. thompson.* This feature of two or more salmonella types being isolated from different chicks in the same outbreak has been noted on more than one occasion. In one outbreak of *S. thompson* studied, *S. anatum* and *S. montevideo* were also isolated from different groups of chicks from the same farm, while *S. pullorum* and *S. thompson* have also been identified in the same outbreak.

An adequate history was available in only one of these outbreaks, when *S. california* was isolated from one of a group of 6 chicks examined. On inquiry it was found that losses had occurred in chicks about 10 days of age, and that 30 chicks had died from a total hatch of 343, or approximately 10 per cent. The premises were not unduly infested with vermin, but a recent supply of grain was found to be heavily contaminated with rat and mouse fæces. A further outbreak occurred on the same farm in a hatch some 3 months later, when *S. california* was again isolated from 3 out of 6 chicks examined. In this case 50 chicks of approximately 3 weeks of age had died in a batch of 150, or 30 per cent. Again the only possible origin appeared to be contaminated foodstuffs or litter, since 100 chicks hatched at the same time and sold to a purchaser showed no mortality. It was also of interest to note that no losses occurred in a group of 100 chicks hatched at a later date and running in the same house, but fed on a different ration.

S. montevideo.

Edwards and Bruner (1943) isolated *S. montevideo* from 11 outbreaks in fowls (Table 1), 1 in swine, 2 in carnivors, and 17 in man. In the U.S.A. it has been isolated from chicks by Jungherr and Clancy (1939), and from turkey poults by Pomeroy and Fenstermacher (1941). In the present survey *S. montevideo* was isolated on two occasions. Attention has already been drawn to the first outbreak in which *S. thompson* and *S. anatum* were also involved. Although mortality was low (approximately 10 per cent.), it continued throughout four hatches. From the first hatch *S. thompson* was isolated, from the following hatch

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a salmonella organism of the *para* C. group, but not further identified, was isolated from 4 out of 10 chicks sent for examination. *S. montevideo* was isolated from the third hatch, and *S. anatum* from the hatch of a fortnight later. There was no sign of vermin-contaminated foodstuffs, but the owner stated that the losses coincided with the use of a new consignment of chick mash. A bacteriological examination was carried out on a sample of chick mash, but with negative results.

S. montevideo was also isolated from a group of chicks sent direct from a small poultry farmer, and from whom no history could be obtained.

S. bareilly.

In Edwards' and Bruner's survey (1943), *S. bareilly* was one of the most commonly encountered organisms, and was isolated from 47 separate outbreaks in poultry. It has also been reported in chicks by Jungherr and Clancy (1939), and in turkey poults by Pomeroy and Fenstermacher (1941). The outbreak of *S. bareilly* in this survey occurred in two consecutive hatches of chicks on the same farm in South Wales. Losses were approximately 12 per cent.; 25 chicks died in the first hatch of 224 chicks and 25 in the second hatch of 194 chicks. *S. bareilly* was isolated from 5 out of 7 chicks examined.

Symptoms started about the seventh day after hatching. There was inappetance, chicks huddled under the hover canopy and showed a sticky diarrhœa. Symptoms persisted for 5-6 days before death, but a number of affected chicks recovered spontaneously and thrived well. There was no evidence of vermin on the farm, and losses coincided with the feeding of a new consignment of food. A sample of this food was submitted by the owner to the county public health laboratory, who reported the isolation of a "Gram-negative, non-lactose fermenting organism which agglutinated composite salmonella serum in dilutions of 1/20 and 1/40. No agglutination was obtained with *S. newport, S. aertrycke, S. enteritidis* and *S. paratyphosum C* sera."

S. anatum.

This organism was obtained on only one occasion, and then from a group of chicks from the farm on which *S. thompson* and *S. montevideo* were also isolated. In America *S. anatum* is regarded as one of the commonest causes of paratyphoid infection of poultry. Edwards and Bruner (1943) obtained 70 cultures from 44 outbreaks in poultry, and also recorded the occurrence of this organism in swine, rodents, carnivors and man. Rettger and Scoville (1920) isolated the organism from an outbreak of almost 100 per cent. mortality in 3,000 ducklings. This infection was called keel disease, in view of the common symptom in ducklings of "keeling over" on their backs before death. It was first reported in chicks by Edwards (1929) and in turkey poults by Pomeroy and Fenstermacher (1941). In this country *S. anatum* was reported by Gaiger and Davies (1930) to be the cause of an outbreak of disease in chicks, but on later examination by Lovell (1932) and Hole (1932) the organism was found to be *S. enteritidis.*

The outbreak in which *S. anatum* was isolated has already been described under *S. montevideo.*

In a report from the Ministry of Agriculture's Veterinary Laboratory, at

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Edinburgh, J. E. Wilson (private communication) states that from 1927-39, salmonella organisms other than *S. pullorum* and *S. gallinarum* were rarely encountered. From 1939 until March, 1944, only one case of salmonellosis was recorded. During the first seven months of 1944, 12 outbreaks were encountered in Scotland and 13 in the five northern counties of England, which are served by the Edinburgh laboratory. From these 25 outbreaks, *S. thompson* was isolated on 14 occasions and *S. typhi-murium* on 9 occasions. The remaining 2 outbreaks were mixed infections of *S. thompson* and *S. typhi-murium*. *S. thompson* was isolated 9 times from chicks and twice from ducklings, and *S. typhi-murium* on 5 occasions from chicks, once from ducklings and once from turkey poults.

Two of the outbreaks were in hatcheries, and in one case each consignment of chicks placed in the brooder house over eight successive weeks was affected. In most cases the origin of the infection was obscure, although in one of the hatchery outbreaks, *S. thompson* was isolated from mice caught on the premises and *S. typhi-murium* from mouse fæces obtained from sealed bags of dried milk powder.

The figures from the Scottish laboratory, although small, also show a very sudden and marked increase in the incidence of salmonella infection in chicks.

Discussion

It is obvious from the foregoing data that in the course of routine examinations of chicks at the Ministry's Veterinary Laboratory there has been during the last three years a noticeable increase in the number of outbreaks of disease caused by organisms of the salmonella group other than *S. pullorum* and *S. gallinarum*. Whether this is a true rise in the incidence of salmonella infections is difficult to say, since it has accompanied an increase in the activities of the State Veterinary Service in the investigation and control of poultry disease generally, with a resultant increase in the number of specimens received in this laboratory for examination. Salmonellosis is the third most important infectious disease of chicks, but in view of the very extensive losses which occur in many individual outbreaks, and the widespread secondary outbreaks which have resulted from hatchery infections, it is probably second only to bacillary white diarrhœa as a cause of economic loss from infectious disease in chick rearing.

Apart from this apparent increase in the occurrence of salmonellosis, the most noticeable feature has been the isolation, during the past two years, of salmonella strains not hitherto reported in poultry in Great Britain. Two of the strains recorded in this survey, *S. typhi-murium* and *S. enteritidis*, have been recognised for many years as the cause of outbreaks of disease in chicks and ducklings, both in this and other countries. Their importance from the public health aspect has also been stressed, particularly in Europe. In the annual reports of the C.M.O. of Health for 1926, 1931, 1932, 1934, 1935, 1937 and 1938, reference has been made to the danger of salmonella infection in man from the consumption of improperly cooked duck eggs. In a recent publication, Gordon and Buxton (1945 B) report a fatal case of salmonella food poisoning in man following the consumption of a fried duck egg. In this case *S. typhi-murium* was recovered from the patient's blood and fæces, from 3 out of 16 eggs laid by

the 4 ducks comprising the flock, and from the ovaries of 2 and the bowel of another of the 4 ducks.

In America many workers have recorded the isolation of salmonella organisms from poultry, and 42 different types have been listed (Edwards and Bruner, 1943). Edwards and Bruner (1939) stated that in America poultry were the greatest reservoir of salmonella organisms, and it may be of some significance in assessing the possible origin of this sudden appearance of new types in poultry in Great Britain to note that with the exception of *S. thompson* all the new types encountered, *S. bareilly, S. california, S. montevideo,* and *S. anatum,* are comparatively common in poultry in the U.S.A.

It may be that the appearance of these strains in poultry in this country during recent years is associated with war-time feeding, such as camp or canteen swill, household refuse, and the large-scale movements of populations to rural areas. That infection can occur in this manner has been amply demonstrated in the case of bacillary white diarrhœa, and it has been shown experimentally that the feeding of incubator refuse, uncooked swill and bakers' waste can not only give rise to heavy mortality when fed to chicks, but may also produce a high percentage of carriers when fed to adult stock. This may be the explanation of the widespread occurrence of *S. thompson,* which has been recognised as a common cause of salmonella food poisoning in man, since first identified by Scott (1926). The same worker (1939) also recorded the presence of this organism in the mesenteric lymph glands of healthy pigs at slaughter, and infection in poultry may have originated from the feeding of uncooked or improperly cooked canteen or camp swill contaminated by infected human beings, or containing material from infected pigs. Canteen or camp swill is not usually fed to chicks, and infection may have been indirectly transmitted to chicks by foodstuffs contaminated by adult fowls, trafficked by attendants, or directly from infected attendants (Hinshaw, *et al.,* 1944), or disseminated by vermin. Since there appears to be no previous record of the isolation in man or animals in this country of infection with *S. bareilly, S. california, S. montevideo,* and *S. anatum,* the most probable source would appear to be processed egg material from America. These organisms are known to be common in that country, and it has recently been reported (*B.M.J.,* 1945) that spray dried egg may be infected with salmonella organisms. Such infected processed egg may be fed to poultry in swill, or, as is known to be the case, mixed in the unconstituted state with chick and poultry meal by the poultry farmers in an attempt to increase the protein level of the ration. A point of importance here is the isolation of more than one type of salmonella organism from the same outbreak. It is improbable that dried egg has been the source of the recent outbreaks of *S. thompson,* since that organism is rarely found in America, and in Edwards' survey was only isolated on one occasion, and then from an adult fowl. In addition to the numerous sources from which poultry may have become infected, especially during war time, it is probable that the general health of young chicks may not have been as good as usual. During the last 3-4 years the quality of chick foods has deteriorated, and the number of chicks examined at this laboratory which had large quantities of undigested food material in the intestines has increased. It is possible that conditions which tended to lower the resistance of chicks, increased the danger from infection with salmonella organisms.

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So far the epidemiology of salmonellosis is not clear. There is some evidence to suggest that in ducks, egg transmission may occur, and organisms of the salmonella group have been isolated from duck eggs (Scott, 1932; Warrack and Dalling, 1933; Beller and Reinhardt, 1934; Kathe and Lerche, 1936; Gordon and Buxton, 1945 B; and others). In a study of an extensive outbreak in ducks, Gordon and Garside (1944) were unable to isolate any salmonella organisms from 2,000 eggs laid by carrier ducks, although the causal organism was recovered from the ovaries of 50 per cent. of the ducks examined; nor were they able to reproduce the condition in ducklings in two breeding experiments. They suggested that if egg transmission does occur it is of secondary importance, and that in most outbreaks infections originate from vermin.

So far, there is no record of the isolation of salmonella organisms from hen eggs, and in an investigation into *S. thompson* infection in chicks, Gordon and Buxton (1945 A) suggested that infection may have originated in the hatching machines by contamination of the outside of the egg shell with infected fæces and subsequent penetration of the shell. Further experimental work now in progress on the epidemiology of *S. thompson* infection in poultry substantiates this hypothesis. So far some 700 eggs laid by 30 pullets and 30 adults, all survivors of *S. thompson* outbreaks, have been examined bacteriologically. No salmonella organism has as yet been isolated from egg meat by the method described by Gordon and Buxton (1945 B), but *S. thompson* has been isolated on a number of occasions from swabs taken from the outside of the egg shells. That carriers of *S. thompson* exist among adult poultry has also been shown, since from rectal swabs taken periodically from these survivors, *S. thompson* has been isolated on a few occasions. The same organism has also been isolated from 24 out of 138, or 17.8 per cent., of random samples of fæces taken from the chicken houses.

The possibility of controlling infection by the detection and elimination of carriers by means of agglutination testing with a homologous antigen is also being investigated. The fluctuation in titre shown by adult survivors of an outbreak is considerable and may detract from the practical value of such a test. It has been observed that at any one test a bird may give a negative result, and yet when a *post-mortem* examination was carried out soon afterwards it was possible to isolate the organism from the tissues (Gordon and Garside, 1944, and Gordon and Buxton, 1945 B).

The isolation of a variety of salmonella organisms from poultry is of considerable importance from the public health aspect, since poultry may become an important reservoir of salmonella infection for man. From the veterinary viewpoint it is of importance, since it has been shown to be a serious cause of mortality and economic loss in chicks. The accurate typing of strains isolated from the field is essential in tracing the probable sources of origin, and a necessary adjunct to the control of infection in poultry flocks.

Veterinary control is complicated by the prevalence with which adult poultry can carry these organisms without any apparent ill effects, and by the fact that with modern intensive methods of management the survivors of an outbreak may number some thousands of chicks, which through the day-old chick trade can create a widespread distribution of infection. Routine blood testing of all poultry

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flocks for the detection of carrier adults does not appear to be a practical proposition, and even in flocks where the strain of salmonella involved has been established the agglutination test seems to be of limited value. At present the control of salmonellosis depends on improved hygiene, particularly in hatcheries, on the eradication of vermin, on the use of vermin-proof foodstores, and on the adequate cooking of swill foods.

Summary

(1) During the period 1933-44, out of a total of 6,578 groups of chicks examined, 273 (4.1 per cent.) were infected with salmonella organisms other than *S. pullorum* and *S. gallinarum*.

(2) There has been a definite increase in the occurrence of avian salmonellosis during the last three years of the period under review, and it is now second only to *S. pullorum* as a cause of fatal septicæmia in young poultry.

(3) The strains of salmonella organisms isolated were *S. pullorum, S. gallinarum, S. typhi-murium, S. thompson, S. enteritidis, S. california, S. bareilly, S. montevideo* and *S. anatum*.

(4) Chicks and ducklings were the species of poultry most commonly affected, but salmonella organisms were also isolated from adult fowls, ducks, turkeys, turkey poults, goslings, pheasant chicks, pigeons, guinea-fowls and a sparrow.

(5) The occurrence of *S. california, S. bareilly, S. montevideo* and *S. anatum* among poultry in Great Britain is reported for the first time.

(6) The importance of avian salmonellosis is stressed, both from the agricultural and public health points of view. The epidemiology is discussed and suggestions made regarding methods of control and eradication.

Addendum

Since the completion of this survey, *S. london* has been isolated from an outbreak of disease in chicks.

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PLASMA BILIRUBIN IN THE HORSE

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IT is a matter of common observation that the plasma of horse blood is coloured a very much deeper yellow than that of most other species. The difference is particularly striking when horse plasma is compared with sheep or cattle plasma, but is usually also noticeable with human or dog plasma. The investigations reported in this paper were initiated primarily with the object of ascertaining what pigment was responsible for the high colour of horse plasma, but when the interesting effect of fasting was observed, it was naturally also included in the report, since it may have some slight bearing on pathological equine conditions in which there is a loss of appetite.

Methods

Blood specimens for all the analyses were drawn from the external jugular vein into dry, oxalated flasks. The plasma was separated as soon as possible by centrifuging. In spite of precautions to avoid or minimise hæmolysis, a few specimens, on examination with the spectroscope, showed the characteristic absorption spectrum of oxyhæmoglobin. Such specimens were all discarded.

Spectroscopic observations were made with a Beck Hartridge reversion spectroscope, the drum being graduated directly in Ångström units and calibrated with the neon lamp supplied by the manufacturer. Unfortunately, the broad and diffuse nature of the absorption bands examined made it impossible to measure their position with the full precision of which the instrument is capable.

All other optical measurements were made with a Zeiss Pulfrich step-photometer. This is a visual photometer equipped with a series of filters covering the entire range of the visible spectrum in bands of 35-40mμ.

The bilirubin sample used for comparison purposes at various stages was prepared from dog bile, which is particularly rich in this pigment. The method used was that outlined by Hawk and Bergeim (1938).

Quantitative bilirubin determinations were made by the method of Haslewood and King (1937). No difficulty was experienced in getting duplicates to agree within 1-2 per cent. Owing to the difficulty of obtaining an authentic specimen of pure bilirubin for use as a standard, it was necessary to employ the methyl red standard recommended as an alternative by the originators of the method. Several samples of methyl red from different sources agreed very well, and on test the sample of bilirubin prepared from dog bile appeared to be about 93 per cent. pure. It was concluded that no serious error would arise from the use of either the analytical method or the bilirubin.

Experimental

Spectroscopic examination of horse blood plasma shows a broad and intense absorption band in the blue-green and blue, which appears to have its maximum in the region of 480 mμ. This band seems to have been originally noted by Heilmeyer (Heilmeyer and Toop, 1934), but he made no further investigation of it, perhaps because he was chiefly interested in human plasma. Human plasma shows a much less well-defined band which has its maximum rather nearer the red end of the spectrum, and in some cases absorption appears to be almost continuous from about 490 mμ. down to the lower limit of visibility. Sheep and cattle plasmas do not absorb nearly so strongly in this region, and

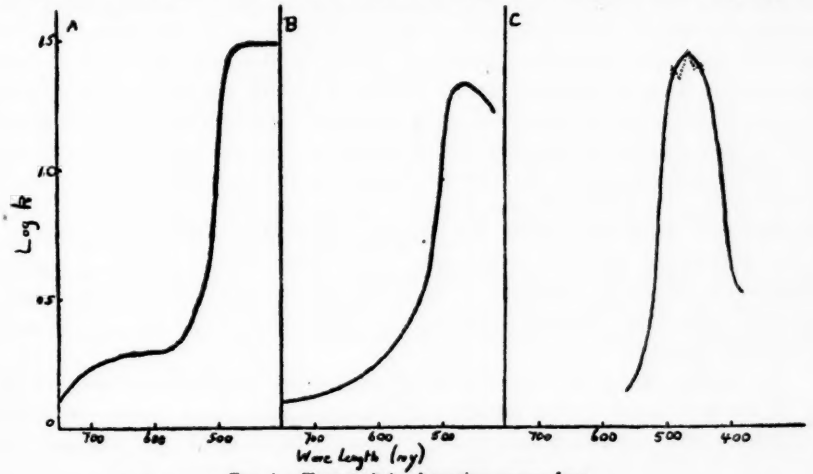

FIG. 1. Characteristic absorption curves for:
A. 1 mg. per 100 ml. bilirubin in phosphate-carbonate buffer, *pH* 7.4.
B. Typical horse plasma, 0.72 mg. bilirubin per 100 ml.
C. Mixed carotenes from plant source (curve reconstructed from Morton, 1942).

no actual absorption band is seen, even when a thick layer of plasma is used to compensate for the pale colour.

It appeared from these qualitative observations that much, at least, of the colour of horse plasma was due to some pigment or pigments absorbing mainly

in the spectral region between 490 and 440 mμ. The most obvious of such pigments include bilirubin, which is responsible for most of the colour of human and dog plasma, and various carotenoid compounds, which have been known for some time to occur in small amounts in human plasma (cf., for example, Hoch, 1943). It should, however, be remembered that observations with the direct vision spectroscope do not exclude the possibility of the presence of compounds which do not absorb sufficiently strongly in any particular spectral region to show a definite absorption band. It was therefore thought desirable to measure with the Pulfrich photometer some characteristic absorption curves for a number of plasmas. One of these is illustrated in Fig. 1, along with two other curves given for comparison: the curve obtained from the specimen of bilirubin prepared from dog bile, and a curve for a mixed carotene sample, redrawn from data given by Morton (1933). The bilirubin was dissolved in M/20 sodium carbonate solution, and M/10 potassium dihydrogen phosphate was added until the *pH* approached the physiological level of 7.4. The optical measurements were then made as rapidly as possible, because the solution became turbid within an hour or so, and most of the bilirubin was precipitated in 24-36 hours. Morton's work was done with a very much more sensitive instrument than the Pulfrich photometer, and his original curve showed the typical triple peak associated with such compounds. The Pulfrich photometer, however, would not detect this, so the curve was redrawn to bring it into line with the measurements of the author.

Inspection of Fig. 2 shows that although there is a broad resemblance between the three curves, that from horse plasma is by no means identical with either of the others. The absorption spectrum of bilirubin, however, seems to be remarkably variable. The literature abounds with accounts which frequently conflict with one another, but it is possible to state that in most solvents continuous absorption is observed from 510-490 mμ. down to the lower limit of visibility. Certain workers (Heilmeyer, 1931; Müller and Engel, 1931) have been able to prepare solutions in chloroform or alcohol which show bands with maximum absorption at about 450 mμ. In human plasma there is an ill-defined band with a maximum probably in the region of 490-480 mμ. The variations are doubtless due in great measure to the ease with which bilirubin is oxidised, to its tendency to form colloidal solutions, and to the difficulty of preparing the pigment in a really pure state. In addition, when plasma is the solvent, there is the well-known fact (cf., Stenhagen and Teorell, 1938) that bilirubin forms complexes with plasma albumin. It seems not unlikely that such complex formation may affect the absorption spectrum. The same might be true of many carotenoid pigments.

In another series of experiments simultaneous measurements were made on 77 horse plasmas of the intensity of the absorption band (measured as the extinction coefficient with a filter transmitting only between 450 and 490 mμ.) and the bilirubin concentration. The bilirubin concentrations turned out to be so high as to merit very considerable attention. In Table 1 the 77 values are summarised, and in Table 2 a brief comparison is given of these determinations with 100 made on human plasma by the same method. The latter are taken from Vaughan and Haslewood (1938). These tables show that on the average there is about three times as much bilirubin in horse plasma as in human plasma. The distribution

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curves and statistical characters of the two series are qualitatively similar, so that the difference is not due to a small number of very large values, nor even to a change in the distribution of less obvious character, but simply to an overall increase of about 200 per cent. It seems worth recording at this point that several specimens of normal sheep and cattle blood were examined at various times, but in no case was it possible to demonstrate the slightest trace of bilirubin.

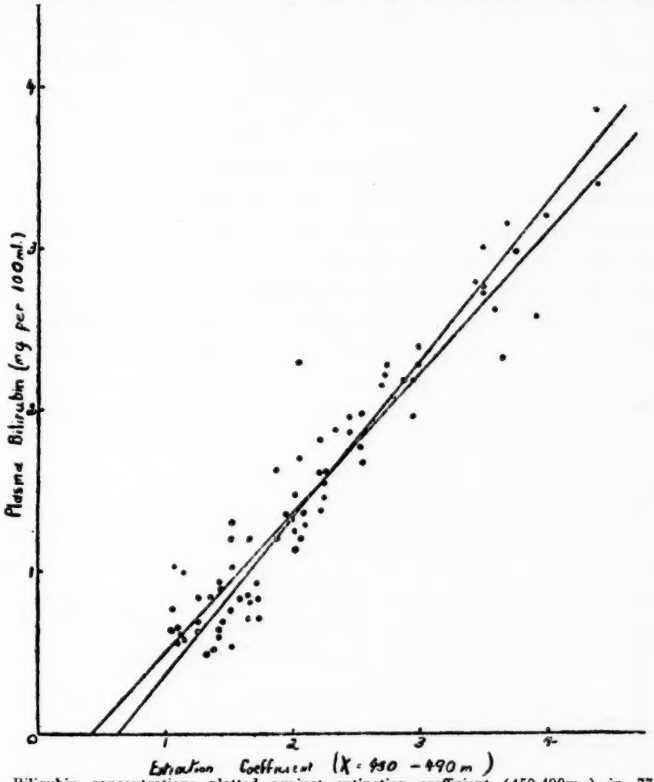

FIG. 2. Bilirubin concentrations plotted against extinction coefficient (450-490mμ) in 77 horse plasma specimens.

The bile of these animals, when fresh, is invariably a pure green colour, and several attempts to prepare bilirubin from it by the method used on dog bile were unsuccessful. It appears probable that bilirubin plays no part in the normal metabolism of sheep and cattle.

TABLE 1.

Plasma bilirubin in the horse.

Bilirubin (mg./100 ml.).	*No. of Horses.*	*Percentage of cases.*
0-0.5	1	1
0.5-1.0	25	32
1.0-1.5	16	21
1.5-2.0	13	17
2.0-2.5	10	13
2.5-3.0	7	9
3.0	5	7

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TABLE 2.

Comparison of plasma bilirubin concentrations in man and horse.

	Plasma Bilirubin in	
	*Man.**	*Horse.*
No. of cases	100	77
Mean	0.54 mg./100 ml.	1.57 mg./100 ml.
S.D.	0.25 mg./100 ml.	0.86 mg./100 ml.
Lowest value	0.2 mg./100 ml.	0.48 mg./100 ml.
General	94% < 1 mg./100 ml.	67% > 1 mg./100 ml.
Distribution	In both species the distribution curve is biassed in favour of low values.	

* From Vaughan and Haslewood (1938).

The analyses recorded in Table 1 showed the presence of large quantities of bilirubin in horse plasma, but they did not bar the possibility of the simultaneous presence of considerable amounts of carotenoid pigment or other material absorbing in the same spectral region. Evidence on this point was obtained by plotting the bilirubin concentration against the extinction coefficient over the range 450-490 mμ. for each of the 77 horse plasmas referred to above. The

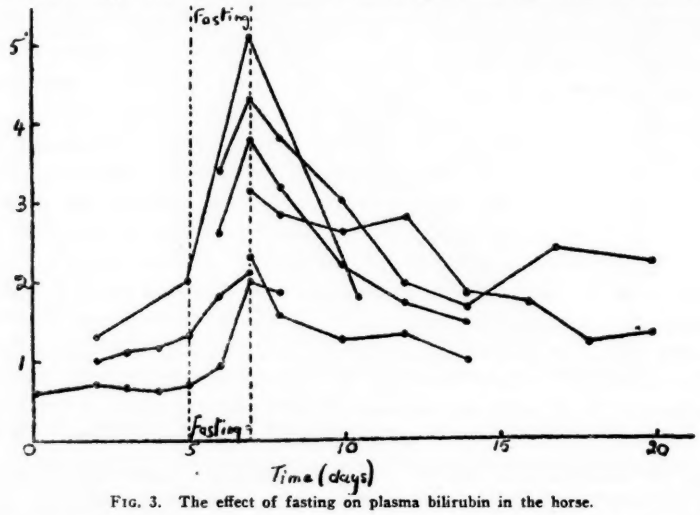

FIG. 3. The effect of fasting on plasma bilirubin in the horse.

results are shown in Fig. 2. There is obviously a very high correlation between the two sets of values ($r = 0.948$). The two straight lines are the pair of regression lines.

$x = 1.032y + 0.607$ and $y = 0.871x - 0.370$, where x represents the extinction coefficient and y the bilirubin concentration. The figure indicates clearly that almost the whole of the material absorbing between 450 and 490 mμ. is bilirubin, but the fact that the regression lines do not embrace the origin shows that there is, as might be expected, a small residual amount of non-bilirubinoid pigment which absorbs in the same spectral region, but does not react with the diazotised sulphanilic acid reagent. There is no further evidence available as to the nature of this residual pigment, but variations in its quantity

probably account largely for the easily discernible fact that the points in Fig. 2 show a good deal more "scatter" than is warranted by the analytical errors (both measurements can be made with an error which does not usually exceed 2 per cent.).

In the later stages of the work it became possible, through the courtesy of certain colleagues, to obtain blood specimens at intervals from horses which were fasted for 48 hours prior to slaughter or operation. In most cases it was possible to determine plasma bilirubin over a considerable period, and although the total number of animals involved was only 7, the results, which are summarised in Fig. 3, were quite clear cut. Fasting, as may be seen from this figure, causes a marked rise in plasma bilirubin in the horse. The greatest increase observed was from 1.96 to 5.1 mg. per 100 ml., and 4 days after the conclusion of the fast the value had fallen again to 1.80 mg. per 100 ml. Fig. 3 gives the impression that the recovery was usually much slower than the initial rise, but this may have been due to the fact that all the animals which were permitted to survive the fasting period were subjected to chloroform anæsthesia. Chloroform has pronounced effects on the liver, and may have impaired the rate of elimination of bilirubin by that organ.

It is difficult in the present state of knowledge to offer any detailed explanation of this phenomenon, but it may very well be associated with the fact that the horse has no gall-bladder.

Summary

(1) Horse plasma shows a strong absorption band with a maximum at about 480 mμ. In other herbivorous domestic animals the band is very weak or absent.

(2) Horse plasma contains three times as much bilirubin as human plasma. In a series of 77 cases the mean was 1.57 mg. per 100 ml., and the standard deviation 0.86 mg. per 100 ml. Sheep and cattle plasmas appear to contain no bilirubin.

(3) There is such close correlation between bilirubin concentration and absorption over the range 450-490 mμ. that there can be no doubt that the band is due to the presence of bilirubin.

(4) Fasting for 48 hours causes a marked increase in plasma bilirubin in the horse.

A preliminary account of this work was read before a meeting of the Biochemical Society at Glasgow in July, 1945.

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PRELIMINARY OBSERVATION ON THE MODIFICATION OF A STRAIN OF NEWCASTLE DISEASE VIRUS BY INTRACEREBRAL PASSAGE THROUGH DUCKLINGS*

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Introduction

The possibility of modifying certain viruses by passage and in particular the effect on certain viruses of intra-cerebral passage in a species not ordinarily susceptible to subcutaneous inoculation are well-known. In the experiments to be described this principle of modification by passage was employed in an attempt to produce a modified neurotropic Newcastle Disease virus, the end in view being to obtain a virus capable of immunising susceptible fowls against Newcastle disease without producing symptoms of that disease.

The virus used in this work was recovered on 21/1/45 from an outbreak of disease in fowls in Northern Palestine characterised by respiratory-nervous symptoms and associated with over 80 per cent. mortality. At post-mortem examinations petechial hæmorrhages were noted on serous and mucous membranes; they were most constantly found on the mucous membrane of the proventriculus and doudenum and on the heart beneath the pericardium. Bacteriological cultures from liver, heart and spleen of affected fowls were negative. Intramuscular inoculation of 0.1 c.c. of a 1 :15 composite emulsion of liver, spleen and brain regularly caused a fatal disease in inoculated fowls. The causal agent was found to pass through a Seitz filter.

The average period of survival of inoculated fowls was five days. Pigeons, young and old, were found to be susceptible to intramuscular inoculation. The inoculated pigeons showed typical symptoms of Newcastle disease. The symptoms were characterised by paralysis of the wings and legs, retraction of the head, and occasionally profuse discharge of a viscid fluid from the buccal cavity. The average period of survival of pigeons inoculated intramuscularly was eight days. Serum collected from a bird which had recovered from a natural infection completely neutralised the experimental virus, but failed to neutralise typical Fowl Plague virus.

From 21/1/45 to 17/3/45 the virus was maintained by serial passages in fowls. On 17/3/45 pieces of liver, spleen and brain were dried from the frozen state and preserved in sealed ampoules in the freezing chamber of a refrigerator.

Selection of a Host

(a) *Mouse*

The work of Kraneveld and Nasoetion, quoted by Beaudette (1943) showed that the virus of Newcastle Disease cannot be established in mice.

(b) *Pigeon*

The pigeon is generally recognised as being very susceptible to Newcastle

* Published with the kind permission of the Chief Veterinary Officer, Government Veterinary Service, Palestine.

Disease virus inoculated intramuscularly, and an attempt by Piccard and Shirlaw, quoted by Beaudette (1943), to modify the virus in pigeons gave negative results.

(c) *Duck*

The duck is much more resistant than the fowl to natural infection with Newcastle Disease virus, and ordinarily cannot be infected by intramuscular inoculation. Some birds will even resist intravenous inoculation (Purchase, 1931; Dobson, 1939). Furthermore, Doyle (1927) was unable to infect fowls with the mouth exudate of a sick duck.

It would appear, therefore, that Newcastle Disease virus may be modified in the duck, and for this reason this bird was chosen as a likely subject for further investigation.

Preliminary observations were carried out on the susceptibility of ducklings, 4-8 weeks of age, to infection by various routes. Intramuscular inoculation of the virus strain used did not cause disease in two birds when inoculated intramuscularly, but one of two birds was successfully infected by the intravenous route. All of four ducklings inoculated intracerebrally became infected. It was, therefore, decided to passage the virus intracerebrally in ducklings and to study the effect of such serial passage on the virulence of the virus for ducklings and for fowls.

Experimental

(a) *The effect of intracerebral passage in pigeons on the virus of Newcastle Disease*

Prior to the passage of the virus in ducklings it was thought advisable to try to obtain a highly virulent virus, preferably one adapted to brain tissue. For this purpose the fowl virus was passaged intracerebrally in a series of pigeons.

Technique

The two pigeons in the first passsage each received intracerebrally 0.1 c.c. of a 1:15 emulsion of the dried fowl virus. Further serial passages were made as follows:—Half the brain of the sick or dead pigeon was transferred into a sterile mortar and ground in 5 c.c. sterile saline. The emulsion was lightly centrifuged, and 0.1 c.c. of the supernatant fluid was inoculated intracerebrally into the pigeons of the next passage. Pieces of the brain were inoculated into broth and agar before the emulsification to ascertain whether bacterial contamination had occurred.

Results

The Newcastle Disease virus used was carried through nine intracerebral serial passages in pigeons. Details of these passages are recorded in Table 1. The pigeon was found to be highly susceptible to intracerebral inoculation and the disease in that bird was characterised by wing and leg paralysis, retraction of the head and occasionally by profuse discharge of a viscid fluid from the buccal cavity. No macroscopical lesions were noted in the visceral organs at post-mortem examinations.

As a result of the intracerebral passage the virulence of the virus for pigeons was considerably increased. In the earlier passages the period of survival of the inoculated pigeons was four days, but after the fifth passage death supervened within 48 hours of inoculation of the virus.

In the pigeon the virus appeared to be present only in the brain. Fowls

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TABLE I.
Serial intracerebral passage of Newcastle Disease Virus in Pigeons.

No. of passage.	No. of Pigeon.	Inoculum.	Date inoculated.	Date* killed.	Date died.
I	1 2	Fowl virus „ „	27.5.45 „	1.6.45 1.6.45	
II	155 709	Brain, pigeon No. 1 „ „ „	1.6.45 „		5.6.45 6.6.45
III	1202 1264	Brain, pigeon 709† „ „	7.6.45 „	10.6.45	9.6.45
IV	1854 1107	Brain, pigeon 1202 „ „	10.6.45 „	12.6.45 12.6.45	
V	1370	Brain, pigeon 1854	12.6.45		14.6.45
VI	130 4157	Brain, pigeon 1370 „ „	14.6.45 „		16.6.45 „
VII	721	Brain, pigeon 130	16.6.45		18.6.45
VIII	988	Brain, pigeon 721	18.6.45		20.6.45
IX	3189	Brain, pigeon 988‡	25.6.45		27.6.45

* All pigeons when killed showed typical symptoms of the disease.
† Kept in ice chest before inoculation for 24 hours.
‡ Kept in ice chest before inoculation for 5 days.

inoculated with liver and spleen emulsion taken from sick or dead pigeons did not sicken and were not apparently immunised.

(b) *Virulence of the pigeon-passaged virus for fowls*

Pigeon virus, fifth and ninth passage, was inoculated into fowls in order to test whether passage had caused a change in the virulence of the virus for fowls.

TABLE II.
Virulence of Pigeon Passaged Virus for Fowls.

No. of fowl.	Inoculum.	Dose and route of Inoculation.	Date Inoculated.	Results.	Symptoms and Post Mortem.
2001	Brain, pigeon passage V	0.1 c.c. skin between toes	14.6.45	Died 20.6.45	Typical Newcastle Disease
660	„ „	0.1 c.c. into the wattle	14.6.45	Died 18.6.45	Typical „
899	„ „	0.1 c.c. intra-mascularly	14.6.45	Died 20.6.45	Typical „
2843	Brain, pigeon passage IX	0.1 c.c. skin between toes	27.6.45	Died 2.7.45	Typical „
291	„ „	0.1 c.c. into the wattle	27.6.45	Died 2.7.45	Typical „

The inoculum was made from half of a pigeon brain emulsified in 5 c.c. sterile saline. The emulsion was lightly centrifuged and each fowl received 0.1 c.c. of the supernatant fluid. The results are recorded in Table II.

It will be seen from Table II that nine intracerebral passages of the virus in pigeons had not apparently modified its virulence for fowls.

(c) *Intracerebral passages of the virus in ducklings*

The inoculum in the first passage in ducklings was made from half a pigeon brain (5th passage) emulsified in 5 c.c. saline. Each of four ducklings in the first passage received 0.1 c.c. intracerebrally. Further passages were made as follows: The brain of a sick or dead duckling was transferred to a sterile mortar and emulsified in 5 c.c. sterile saline. The emulsion was lightly centrifuged and 0.1—0.2 c.c. was inoculated intracerebrally. The material was tested for the presence of contaminating organisms before each passage.

Fourteen passages in ducklings were made. The details are recorded in Table III. Ducklings were found to be highly susceptible to the virus when

Serial Intracerebral Passage of Newcastle Disease Virus in Ducklings.

TABLE III.

No. of Passage.	No. of Duckling.	Inoculum.	Date inoculated.	Date of first symptoms.	Date killed.	Date died.
I	149	Brain, pigeon 5th passage	14.6.45	17.6.45		17.6.45
	438	„	„	„	17.6.45	
	140	„	„	„	18.6.45	
	506	„	„	„		18.6.45
II	3075	Brain, duck 506	18.6.45	21.6.45	22.6.45	
III	137	Brain, duck 3075	22.6.45	24.6.45	24.6.45	
	1090	„ „	„	24.6.45		25.6.45 *
IV	4948	Brain, duck 137	24.6.45	27.6.45	28.6.45	
	4853	„ „ 1090	25.6.45	27.6.45		28.6.45
V	1479	Brain, duck 4948	28.6.45	3.7.45	4.7.45	
	1274	„ „ 1274	28.6.45	Found dead.		2.7.45
VI	1470	Brain, duck 1479	4.7.45	7.7.45		10.7.45
	1466	„ „	„	7.7.45	8.7.45	
VII	1462	Brain, duck 1466	8.7.45	12.7.45		13.7.45
	1463	„ „	„	11.7.45	11.7.45	
VIII	147	Brain, duck 1463	11.7.45	13.7.45	13.7.45	
IX	1486	Brain, duck 147	*14.7.45	16.7.45		17.7.45
X	1487	Brain, duck 1486	17.7.45	19.7.45	20.7.45	
XI	11	Brain, duck 1487	20.7.45	22.7.45	23.7.45	
XII	12	Brain, duck 11	23.7.45	25.7.45		26.7.45
XIII	13	Brain, duck 12	27.7.45	29.7.45	31.7.45	
XIV	14	Brain, duck 13	31.7.45	2.8.45		3.8.45
	15	„ „	„	2.8.45		3.8.45

* Kept in the ice chest for 24 hours.

inoculated intracerebrally. Following an incubation period of 2-4 days, the intracerebrally inoculated ducklings showed the following symptoms:—Depression, increased thirst, diarrhœa, ataxia, paralysis of the leg, paralysis of the lower mandible with resulting inability to shut the beak, and encephalitis. In several

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sick ducklings a profuse discharge of a viscid fluid was noted from the mouth. In others the head was retracted or the head and neck were stretched forward along the floor of the cage. Post-mortem examination did not reveal macroscopical lesions in the visceral organs.

(d) *The effect of intracerebral passage in ducklings on the virulence of the virus.*

Duck virus of 5th, 6th, 10th, 13th and 14th passages was inoculated into fowls in order to note whether any change in the virulence had been induced as a result of the intracerebral passage through ducklings.

The inoculum was made up of half the brain of a duckling in 5 c.c. sterile saline. The emulsion was lightly centrifuged and the supernatant fluid was inoculated intradermally into the wattle or into the skin between the toes of the test fowls in doses ranging from 0.1 to 1.0 c.c. The results are recorded in Table IV.

TABLE IV.

Virulence of Duck Passaged Virus for Fowls.

No. of Fowl.	Inoculum.	Dose and Route.	Date Inoculated.	Results.
1275	5th passage virus in ducks	0.1 c.c. skin between toes	4.7.45	Sickened on 8.7.45 died on 9.7.45
1273	"	"		Sickened on 8.7.45 died on 9.7.45
1480	"	0.1 c.c. intradermally into the wattle		Sickened on 8.7.45 died on 9.7.45
1484	"	"		Sickened on 9.7.45 died on 10.7.45
2940	6th passage virus in ducks	0.1 c.c. intradermally into the wattle	8.7.45	Sickened on 14.7.45 died on 15.7.45
4146	"	"		Remained healthy
3578	"	"		Sickened on 13.7.45 died on 14.7.45
101	10th passage virus in ducks	0.1 c.c. intradermally into the wattle	20.7.45	Remained healthy
102	"	0.2 c.c. "		"
103	"	0.1 c.c. "		"
104	"	0.1 c.c. "		"
105	"	0.1 c.c. "		"
106	"	0.1 c.c. "		"
107	"	0.1 c.c. "		"
108	"	0.1 c.c. "		"
101	13th passage virus in ducks	0.2 c.c. intradermally into the wattle	31.7.45	Remained healthy
103	"	"	31.7.45	"
105	"	"	31.7.45	"
107	"	"	31.7.45	"
352	"	0.1 c.c. intradermally into the wattle	31.7.45	"
353	"	"	31.7.45	"
1270	"	1.0 c.c. "	31.7.45	"
2762	14th passage virus in ducks	0.2 c.c. intradermally into the wattle	3.8.45	Remained healthy
385	"	"	3.8.45	"
632	"	0.5 c.c. "	3.8.45	"

Results

It will be seen from this table that four fowls inoculated intradermally into the wattle or into the skin between the toes with 5th duck passage virus all sickened and died. Two out of three fowls inoculated intradermally into the wattle with 6th passage virus sickened and died. Eight fowls inoculated in the same way with 10th passage virus failed to develop the disease. Four of these fowls were reinoculated 11 days later with 13th passage virus and remained healthy. Three fowls inoculated with 13th passage and three inoculated with 14th passage virus remained healthy.

The results obtained appear to indicate that the fowl virus had been so modified by intracerebral passage in ducklings that after 10 passages it failed to produce Newcastle Disease in fowls inoculated intradermally into the wattle.

In ducklings the virus appears to be present in the brain only. Emulsions of the liver and spleen of ducklings of 5th and 13th passage virus inoculated intramuscularly into fowls failed to produce either infection or immunity.

(e) *Immunity produced in fowls by the duck passage virus.*

All the fowls which had been inoculated with virus passaged intracerebrally through ducklings, and which failed to develop Newcastle Disease as a result of

TABLE V (Group 1).

Immunity Test of Fowls—12 days after being treated with duck passaged virus.

No. of Bird.	Date tested for immunity.	Results.	Date discharged.
352	12.8.45	Sickened on 16.8 Recovered on 22.8	
1270	„	Remained healthy	19.9.45
2762	15.8.45	„ „	„
385	„	Sickened on 21.8 Died on 22.8	
632	„	Remained healthy	19.9.45
Normal control	12.8.45	Sickened on 16.8 Died on 17.8	
„	15.8.45	Sickened on 19.8 Died on 20.8	

this inoculation, were inoculated with fowl virus either 12 days later (Group 1) or 18 days later (Group 2).

The results of these tests are recorded in Tables V and VI.

Out of five fowls in Group 1, three failed to develop any symptoms. One

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became affected on the 6th day and showed leg paralysis, but recovered completely subsequently. The remaining bird developed Newcastle Disease and died.

All eight birds in Group 2 remained unaffected by the test dose, whereas all

TABLE VI (Group 2).

Immunity Test of Fowls—18 days after being treated with duck passaged virus.

No. of Bird.	Date tested for immunity.	Results.	Date discharged.
101	7.8.45	Remained healthy	25.8.45
102	"	" "	"
104	"	" "	"
105	"	" "	"
106	"	" "	"
107	"	" "	"
108	"	" "	"
353	17.8.45	" "	19.9.45
Normal control	"	Sickened on 10.8 Died on 11.8	
"	"	Sickened on 11.8 Died on 12.8	
"	17.8.45	Sickened on 21.8 Died on 22.8	

of a group of normal fowls kept in the same room for the duration of the experiment died on the 4th-5th day following the inoculation with the same dose.

Summary and Conclusions

(a) The strain of Newcastle Disease virus used in these experiments was apparently modified by serial intracerebral passage through ducklings.

(b) Fowls inoculated intradermally into the wattle with virus modified by 10 intracerebral duck passages did not develop symptoms of Newcastle Disease.

(c) Fowls inoculated with the modified virus were apparently immunised and resisted an inoculum of fowl virus which killed control birds in 4-5 days.

(d) Immunity to the virulent fowl virus was apparently fully established 18 days after inoculation of the birds with modified duck virus.

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UNITED NATIONS RELIEF AND REHABILITATION ADMINISTRATION

Livestock Disease Control—UNNRA Forms Secretariat

THE first international conference of veterinarians ever held in Australia has just concluded its sittings in Sydney (December 14-17, 1945). The conference was convened by UNRRA in view of the immediate problem of shipping into the liberated countries livestock for rehabilitation. The object was to establish collaboration amongst Pacific nations in controlling infectious animal diseases. It was attended by veterinary representatives of practically all Far Eastern member governments of UNRRA and the commands of Admiral Lord Louis Mountbatten and General MacArthur. Decisions reached by the conference are likely to have important results for Australian livestock.

These include the establishment by UNRRA of a Secretariat, which, at the request of the veterinary representatives of the Far Eastern nations, will collect and publish statistics on epizootic diseases, and will provide for prompt reporting of outbreaks of diseases likely to sweep from one country to another. In addition, the Secretariat will collect and publish information on other aspects of the livestock industry, such as the presence in various countries of animals particularly adapted to tropical conditions or having resistance to disease.

The conference requested UNRRA to develop the UNRRA South-West Pacific Area International Veterinary and Livestock Secretariat as a branch of whatever world organisation is ultimately set up by the United Nations.

Thus the work of the Secretariat may be continued for normal disease control and trade purposes after UNRRA has completed its relief and rehabilitation tasks.

Rebuilding of flocks and herds reduced during the war is a major task of rehabilitation in the Far East. Australia is one country to which devastated nations look for livestock. Co-operation between the veterinary authorities of Australia and importing countries is an essential prelude to the establishment of an export industry.

On the opening day, Sir Robert Wallace, Vice-Chancellor of Sydney University, addressed the conference, which, he said, was a good omen for international co-operation in facing problems of the Pacific. He afterwards entertained the veterinary representatives at lunch, and said he would welcome at Sydney University students from all over the Pacific.

Mr. Geoffrey C. Remington, Acting Director of UNRRA, South-West Pacific Area Office, who was elected chairman of the conference, spoke of the needs for veterinary services in relief and rehabilitation of war-damaged countries. He said that because of the breakdown of veterinary services, emergency slaughtering for food, overwork of animals, and actual destruction by military operations, livestock were almost wiped out in some parts of war-devastated countries. Diseases which arose under such conditions threatened the livestock industries of all neighbouring countries.

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Countries of small farms, such as China and the Philippines, needed an urgent measure of protective relief to rehabilitate livestock industries. Countries which could produce food would then be strong enough to tackle the rehabilitation of other industries and general economic reconstruction. Until they could produce food for themselves they were dependent on relief gifts of food from a world in which at present food shortages were general.

UNITED NATIONS RELIEF AND REHABILITATION ADMINISTRATION —SOUTH-WEST PACIFIC AREA

Formation of International Veterinary and Livestock Secretariat for the Far East

(Report by Professor I. Clunies Ross, D.V.Sc., Dean, Faculty of Veterinary Science, University of Sydney.)

At a conference of Far Eastern member governments called by the United Nations Relief and Rehabilitation Administration for the South-West Pacific Area, at Sydney, Australia, in December, 1945, it was decided to set up an UNRRA, SWPA, International Veterinary and Livestock Secretariat.

The functions of this body will include the collection and dissemination of information relating to the incidence and control of disease in member countries, the adoption of uniform methods of health certification, the provision of an information service in relation to general animal husbandry problems, and encouragement of interchanges of veterinary personnel for post-graduate training or other purposes between member countries, and the supply of veterinary aid to member countries in case of emergency.

The conference was attended by representatives of: Australia, China, India, Netherlands Indies, New Zealand, Philippines and the United States of America, and the American and British Far Eastern Commands.

The Executive Officer of the Secretariat is Major William Granger, B.V.Sc., and its address is: c/o. UNRRA, SWPA, 52, William Street, Sydney, N.S.W., Australia.

International Veterinary and Livestock Secretariat for the Far East

(Report by Professor I. Clunies Ross, D.V.Sc., Dean, Faulty of Veterinary Science, University of Sydney.)

It is obvious that the rehabilitation of war-ravaged countries must include the restoration of their livestock industries. Livestock are essential, not only for the supply of food, but equally for clothing, transport and agriculture.

In many countries in the Far East the livestock population has been greatly reduced as the result of the war, and, pending the recovery to normal numbers, general rehabilitation must be seriously handicapped. The restoration of the livestock industries will, however, be greatly retarded if further losses are caused by enzootic diseases, by diseases introduced by livestock from other countries, and no less by malnutrition or inefficient breeding practices.

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With these facts in mind, a meeting of the Council of UNRRA for the Far East, held at Lapstone, N.S.W., Australia, in February, 1945, resolved:

> "That draft proposals for the establishment of a veterinary consultative body for the Far East be submitted immediately to member governments for their consideration, and in the event of their agreement to the principle, steps be taken by UNRRA to have a detailed convention drafted for adoption by member governments broadly comparable with that suggested by the panel on veterinary services of the Technical Sub-committee on Agriculture for Europe." (CCFE Sydney, 2, appendix 5, para. 85.)

Pursuant to the above resolution, the Office of UNRRA for the South-West Pacific Area convened a conference of veterinary representatives of Far Eastern member governments in Sydney, Australia, from December 14 to 17, 1945.

The conference asked that the UNRRA, SWPA, International Veterinary and Livestock Secretariat undertake functions which may be summarised as follows:

(1) The preparation by arrangements with member countries of check lists of communicable diseases of livestock of economic importance of virus, bacteriological, protozoal, and metazoal origin, such lists to include indications of the prevalence and distribution of the diseases listed and the dissemination of such information to member countries.

(2) The publication by the Secretariat for distribution to member countries of monthly statistical bulletins similar to those published before the war by the Office International des Epizooties, incorporating information on the incidence of infectious diseases obtained from member countries, and that copies of this information be sent to the Office International des Epizooties in Paris; the form in which the statistics are presented to be modelled on the practice of the Office International des Epizooties in order to co-ordinate the form of publications of the Secretariat with that of the Office International des Epizooties.

(3) The arrangement for notification by cable of the occurrence for the first time in a member country of scheduled diseases, or any major extension of these diseases into areas previously unaffected.

(4) The preparation by the Secretariat of a suitable standard form to be used by member countries in transmitting the disease information agreed upon and of suitable map forms; the latter being used to show the extent and distribution of the diseases notified.

(5) The collection from and dissemination to member nations of information as to the nature of veterinary organisations in force, the qualifications and types of training undergone by veterinary personnel, and the number of veterinary personnel as contrasted with the number of human and animal population in each of the member countries, and, in addition, the measures adopted within the territories of each for the control of specific infectious diseases occurring therein.

(6) The provision of a general information service to member countries

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on any aspect of livestock industries to those countries, including, in addition to disease matters, those in relation to breeding and feeding of livestock.

(7) Ascertaining from member countries those diseases in respect of which health certification must be provided for imported livestock, and arranging in collaboration with the Office International des Epizooties for the drawing up of standard health certification for this purpose; in this connection the Secretariat to draw the attention of governments to the desirability of extending the scope of certification of livestock intended for import to include, for stud animals, such examination for genital soundness as may appear to the importing country to be desirable; and to request exporting countries to make available for the purpose of livestock for export, such information on type and performance as may be sought.

(8) The preparation for dissemination to member countries of a list of biologicals prepared by, and the methods of manufacture, standards and control within each member country, and the provision for regular exchange of information on items and quantities obtainable for export.

(9) The collection and dissemination of information on:

(a) Facilities available in exporting countries for quarantine, inoculation and testing of livestock, and

(b) Requirements of importing countries in respect of quarantine, inoculation and testing of livestock, and facilities available for these in the country of import.

(10) The dissemination among member countries of information on methods of inspection and certification in member countries of meat, meat products, and of animal products, such as: dairy products, eggs, hides, and skins, hair and wool, intended for export or import, the Secretariat to bring to the notice of member countries the desirability, where this is not already done, of placing inspection and control of meat and meat products, skins, hides and wool, and raw milk, under veterinary supervision.

(11) Facilitating exchanges of administrative, research and other veterinary and livestock workers between member countries and to provide for post-graduate educational facilities in member countries for such workers.

(12) Ascertain whether member countries would, in cases of emergency, due to serious outbreaks of epizootic diseases, favourably consider accepting on loan the services of veterinarians from other member countries, and whether, under such circumstances, member countries would be prepared to make veterinarians available on loan.

(13) The arranging of reports on any temporary veterinary or livestock missions, or permanent missions, working in member countries, whether sponsored by governments or by private enterprise.

(14) The assessment of livestock requirements of member countries, and the available resources of potential exporting countries in respect of these needs: and

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the resources in personnel, equipment and fodder needed to use and care for imported livestock in recipient countries.

(15) Establishing liaison with the Office International des Epizooties with a view to obtaining recognition of the Secretariat as an organisation which might develop in due course into a Far Eastern Pacific branch of a comprehensive world organisation under the control of United Nations.

(16) Inviting the co-operation in, and the support of, the work of the Secretariat of those nations which, although not members of UNRRA, SWPA, have territories bordering on the Pacific Area.

The proposed organisation and functions of the Secretariat will provide a valuable service in all veterinary and livestock matters to Far Eastern and Pacific countries, and will serve to supplement the work of the Office International des Epizooties, in Paris, which, before the war, was not adequately represented in the Far East.

Major William Granger, B.V.Sc., was appointed Executive Officer, and the Office of the Secretariat has been opened at UNRRA, SWPA, 52, William Street, Sydney, N.S.W., Australia.

The Chairman of the conference was Mr. G. C. Remington, Acting Director of the South-West Pacific Area, UNRRA. The Executive Member of the conference was Major W. Granger, of the South-West Pacific Area, UNRRA.

Member governments were represented by:

Australia: R. N. Wardle, B.V.Sc., Director, Division of Veterinary Hygiene, Department of Health, Commonwealth of Australia.

China: C. C. Chen, B.S., D.V.M., Technical Expert of the Ministry of Agriculture and Forestry, Republic of China.

France: Not represented.

India: F. C. Minett, D.Sc., Director, Imperial Veterinary Research Institute, Mukteswar, Kumaun, United Provinces, India.

Netherlands East Indies: A. Luytjes, B.Ag.Sc., University of Wageningen, Holland, Agricultural Engineer, Department Economic Affairs, Batavia, Netherlands East Indies.

New Zealand: D. A. Gill, M.R.C.V.S., D.V.S.M., formerly District Superintendent, Department of Agriculture, New Zealand.
Consultant: E. J. Fawcett, Director General of Agriculture, New Zealand.

Philippines: Vicente Ferriols, D.V.M., Chief, Division of Animal Disease Control, Bureau of Animal Industry, Commonwealth of the Philippines.
Pedro Sales, D.V.M., Chief, Division of Animal Husbandry, Bureau of Animal Husbandry, Commonwealth of the Philippines.

United Kingdom: Not represented.

Union of Soviet Socialist Republics: Not represented.

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United States of America: H. E. Furgeson, D.V.M., formerly Deputy State Veterinarian for Montana.

The Military Commands were represented by:

SACSEA: Lt.-Col. J. B. Girling, South-East Asia Command Liaison Mission.

AFPAC: Col. R. T. Seymour, D.V.M., Veterinary Corps.

Prior to the conference, an advisory group of veterinarians met in Sydney to draw up a tentative agenda for the conference, members of this advisory committee being:

Dr. Clunies Ross: Professor of Veterinary Science, Sydney University.

Dr. Lionel Bull: Chief of the Division of Animal Health and Production of the Council for Scientific and Industrial Research, Commonwealth of Australia.

Mr. R. N. Wardle: Director of Veterinary Hygiene, Department of Health, Commonwealth of Australia.

Dr. D. T. Oxer: Senior Veterinary Officer of the Commonwealth Serum Laboratories, Department of Health, Commonwealth of Australia.

Mr. Max Henry: Chief of the Division of Animal Industry, Department of Agriculture, New South Wales.

LECTURING IN FRANCE

Dr. A. W. Stableforth, head of the Bacteriological Department of the Ministry of Agriculture, left for France on June 18 to lecture for the British Council in Paris, Lyons and Toulouse on bovine diseases, particularly contagious abortion in cattle. This is an acute problem in France at present, and the successful treatment of it is a notable British achievement. The tour has been arranged in co-operation with the French Veterinary Services.

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